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BRIEFER ARTICLES.

A NEW TILLETIA PARASITIC ON ORYZA SATIVA L.

(WITH FIGURES 1–4).

IN December 1898, Mr. Reid Whitford, United States Engineer, Georgetown, South Carolina, sent the writer a few rice plants affected with a Tilletia. The rice plants were taken from a plantation of 250 acres on the Sampit river, about six miles above Georgetown. Three or four other planters on the same river had rice fields affected with the same disease. Mr. Whitford also sent packages of rice flour ground from normal and diseased rice. The flour made from the diseased grain showed a marked dark color. When examined under the microscope, this flour was found to contain numerous large brownish-black opaque spores, the cause of the dark coloration.

The affected spikelets could hardly be distinguished from the normal ones. The greater number of them showed no signs of disease. When the glumes were broken apart, the affected ovaries were found to be made up of a granular mass of spores.

Professor F. S. Earle, of Auburn, Alabama, has kindly assisted me in the identification of the smut fungus, and found it to be *Tilletia corona* Scrib., first described by S. M. Tracy and F. S. Earle as follows:[1]

> Infesting the ovaries, transforming them into black curved horn-shaped masses, sometimes 1^{cm} in length, the outer covering firm in texture, showing traces of the cellular structure of the ovary; spores large, spherical, 22–26 μ, dark fuscous and densely opaque when mature, but covered with a hyaline envelope 2 μ or more in thickness, the surface of the dark central mass covered by minute but deep alveolations, this structure being obscured by the opacity of the mature spore, when the thin alveolar walls can be seen only at the periphery, where they appear like numerous spinous projections reaching almost through the hyaline envelope. The remains of the fruiting hyphæ often persist on the younger spores as a false pedicel. On various grasses, Mississippi, Illinois, Missouri, and Washington, D. C.

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[1] TRACY, S. M. and EARLE, F. S., New species of fungi from Mississippi. Bull. Torr. Bot. Club **23**: 210. 1896.

The following on *Tilletia corona* Scrib., by the same authors, gives the different hosts and localities where this interesting smut has been found:

> This striking smut was first observed by Scribner on *Homalocenchrus oryzoides* and *H. Virginicus* near Washington, D. C., in 1886, and specimens collected by him were distributed by Ellis under the above name in N. A. F.,. as no. 1896. It has since been collected by Waite in Illinois and Missouri on *Homalocenchrus*, on *Panicum virgatum* in Illinois, and by the writers in Mississippi on *Homalocenchrus lenticularis* and *H. Virginicus* at Columbus, on *H. lenticularis* at Bairds, and on *Panicum sanguinale* at Starkville. Specimens on *Panicum virgatum* in the herbarium of the Division of Vegetable Pathology at Washington bear the unpublished herbarium name *Tilletia pulcherrima* Ell. & Gal., but they seem identical with the forms on the other hosts.

The Tilletia infesting the ovaries of the rice plant agrees in most respects with the above description of *Tilletia corona* Scrib. The ovaries become transformed into a black, granular mass of spores. They are, however, seldom hypertrophied or atrophied, but retain to a great extent the form and size of the normal ovaries. They are never curved like the affected ovaries of the other hosts of *Tilletia corona*.

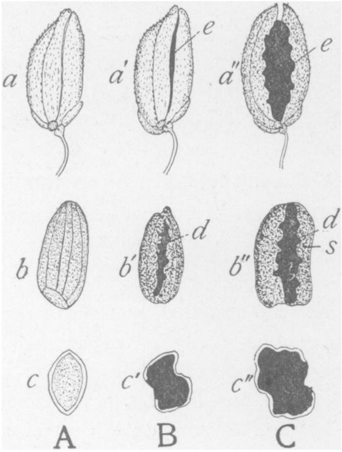

FIG. 1.—*A: a*, normal rice spikelet; *b*, the normal rice grain after the glumes have been removed; *c*, cross section of a normal grain.

B: a', an affected spikelet the glumes of which have been partly pressed apart, exposing the spore mass, *e; b'*, after the glumes have been removed, spore mass exposed at *d*, the fissure in the original ovary wall; *c'*, cross section of a smutted grain filled with spores.

C: a'', an affected spikelet, the ovary of which has been partly hypertrophied; *b''*, after the glumes have been removed, showing *d*, the fissure in *s*, the original ovary wall; *c''*, cross section of the destroyed grain.

As is well known the two glumes of rice spikelets are hard, cover firmly the whole ovary, and remain attached to it when mature. In smutted panicles the affected spikelets are hardly distinguishable from the normal ones, since the destroyed ovaries remain inside of the two glumes, seldom pressing them apart by increased size. The normal and smutted spikelets are often so much alike in their external characters, that when searching for smutted grains in a panicle containing diseased ovaries, diseased spikelets are often mistaken for normal ones. In many spikelets, however, the ovaries become hypertrophied and the two glumes are pressed apart, exposing the grayish or dark destroyed ovary (*fig. 1, C*).

Many ovaries have been but partly destroyed. In these, parts of the grain still remain, while the other parts have been converted into a mass of spores. The greater number have been entirely replaced by the fungus spores. In the totally destroyed grains the spore mass is inclosed only by the epidermis and very thin original wall of the ovary, which is not firm in its texture but can be easily torn off, exposing the black mass beneath (*fig. 1, C, b''*). The affected ovaries are often more shrunken and grooved, otherwise usually of the same size as the normal.

The spores are large and spherical, sometimes broadly elliptical. They are surrounded by a hyaline, cuticle-like envelope, 2–3μ thick. The diameter of the spores, including this hyaline envelope, is from 26–30μ. The color of the spores varies from a deep brown to black. They are covered with numerous projections from the wall, giving them a spinous appearance. These projections extend almost through the hyaline cuticle-like covering. They can be seen best on the less opaque spores. On the opaque spores the projections can be seen only at the periphery. These projections or spines vary in size and form in different spores; sometimes being pointed and curved, but usually more or less blunt. The spores form one granular homogeneous mass inside of the ovaries, with here and there traces of short pieces of mycelium. Two sizes of this mycelium are found. First, broken pieces of brownish septate hyphæ, 4–6μ in diameter (*fig. 2, m*). Second, smaller hyphæ, 2–3μ in diameter, which are sometimes found attached to the spores (*fig. 2, e*). The larger hyphæ are apparently remains of the vegetative mycelium, while the smaller ones are remains of the fruiting or sporogenous hyphæ

Mixed with the mature spores are also found numerous remains of immature spores which have been arrested in their growth. These spores are found in different stages of development. The less developed ones consist only of a shrunken, hyaline cell wall with no contents, projections, or thickenings (*fig. 2, c, d*). In the more developed ones the cell wall appears to be pitted or unequally thickened, many of them showing the projections. They are often filled with granular cell concontents and a nucleus. That they are spores which have been arrested in their growth, there can be no doubt. In *fig. 2. d, e*, are shown two mature spores and two immature ones, all four of them apparently connected by the same fruiting hypha. Out of thirty mounts only one was found to contain the hypha still remaining attached to the immature spores. The immature spores are more numerous in ovaries which have been completely destroyed and converted into spores. They are not so numerous in ovaries that still contain parts of their starch contents. Often 15 to 20 per cent. of the spores incompletely destroyed ovaries are immature and undeveloped, showing that the arrested development of these spores is due to an impoverished nutrition, and probably also to the lack of sufficient space for their complete development.

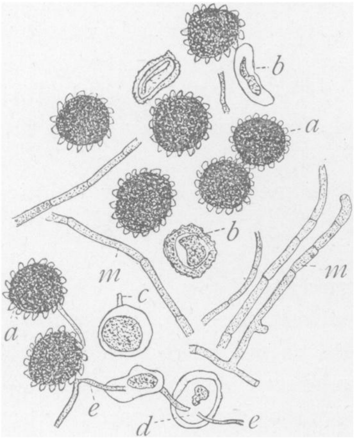

FIG. 2.—*a*, mature spores; *b*, immature spores; *c*, an immature spore with remains of the fruiting hypha; *d*, two immature spores connected with what appears to be a sporogenous or fruiting hypha; *m*, broken pieces of mycelium, evidently remains of the vegetative hyphæ.

Cross and longitudinal sections of the culms were made with a view to finding the smut mycelium and to determining the probable mode of infection. Cross sections of the culms, eight inches below the panicles of the diseased rice plants, showed the presence of a mycelium similar in every respect to the larger one found in the destroyed ovaries. This mycelium is found only in the sub-epidermal vertical rows of loose chlorophyll parenchyma, which lie beneath the rows of stomata in the epidermis. In *fig. 3, B*, are shown bits of mycelium at *m*. The loose chlorophyll parenchyma is connected with the stomata at *g*. In *fig. 4*, the same mycelium is shown in a longitudinal section of the rice culm, eight inches below the panicle.

In cross sections of a rice culm, about one half of the sub-epidermal tissues are stereome, lying between the strips of chlorophyll parenchyma (*fig. 3*, *A*, *c*, and *B*, *s*). The mycelium is never present in this stereome, nor in the fibro-vascular bundles and colorless parenchyma in the interior of the culm.

Cross and longitudinal sections of the rachis also showed the presence of the same mycelium.

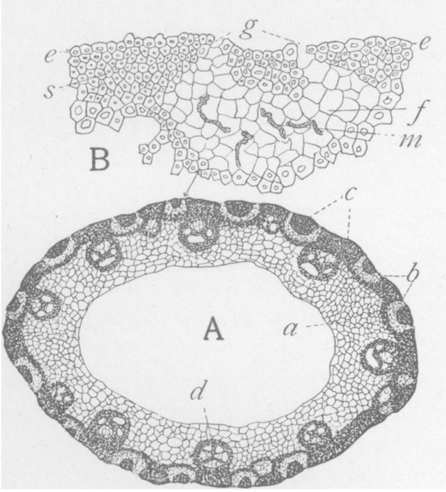

FIG. 3.

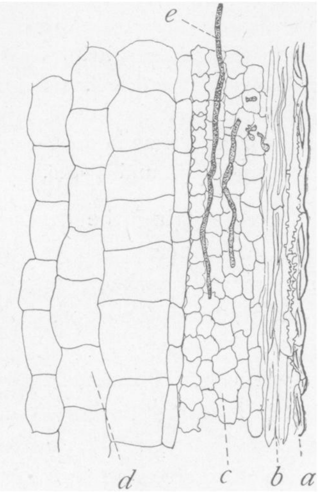

FIG. 4.

FIG. 3.—*A:* Cross section of a rice culm with diseased spikelets, about eight inches below the panicle; *a*, colorless parenchyma; *b*, chlorophyll parenchyma; *c*, stereome; *d*, fibro-vascular bundles.

B: Magnified portion of stereome and chlorophyll parenchyma areas; *e*, epidermis; *f*, chlorophyll parenchyma; *g*, two stomata; *m*, mycelium; *s*, stereome.

FIG. 4.—Longitudinal section of a rice culm about eight inches below the panicle; *a*, epidermis; *b*, stereome; *c*, chlorophyll parenchyma; *d*, colorless parenchyma; *e*, mycelium.

The presence of this mycelium in the rice culms shows, no doubt, that this smut infects the rice plant in the same way that *Tilletia lævis* Kühn and *T. caries* Tul. infect the young seedling at the time of the germination of the wheat grain.

I have not been able, as yet, to germinate the spores, hence no infection experiments have been performed.

As far as I know, no smut has heretofore been reported on the rice plant in America.

In 1896, Y. Takahashi described a new species of Tilletia (*T. horrida*) on the rice plant in Japan,[2] as follows:

> Spore-masses pulverulent, black, produced within the ovary and remaining covered by the glumes. Spores globose, irregularly rounded, or sometimes broadly elliptical, the round ones 18.5–23 μ in diameter, and the elongated ones 22.5 – 26 × 18 – 22 μ in size.
>
> Epispore deep olive-brown, opaque, thickly covered with conspicuous spines. The spines hyaline or slightly colored, pointed at the apex, irregularly polygonal at the base, more or less curved, 2.5 – 4 μ in height, and 1.5–2 μ apart at their free ends. Sporidia filiform or needle-shaped, curved in various ways, 10–20 in number and 38–53 μ in length. *Hab.* On *Oryza sativa* L. From Tōkyō and Kyōto.

By comparing the descriptions of *T. horrida* Tak. and *T. corona* Scrib., it appears that the two are identical; agreeing not only in their size, but in their other characters as well, except that attempts at germinating the spores of *T. corona* have, as yet, given negative results.

One other Tilletia, *T. Oryzæ* Pat., has been reported on the rice plant.[3] It forms spores 3–5 μ in diameter. Brefeld has made a careful study of *T. Oryzæ* Pat., and found it to belong, not to the Ustilagineæ, but to the sclerotia-forming Ascomycetes, since it forms sclerotia inside of the rice grain.[4]

I am indebted to Dr. A. C. True of Washington, to Director Wm. Trelease, and to Mr. J. B. S. Norton, of the Missouri Botanical Gardens, and to Professor F. S. Earle, of Auburn, Alabama, for kindly supplying me with references.—ALEXANDER P. ANDERSON, *Clemson College, S. C.*

[2] TAKAHASHI, Y. On *Ustilago virens* Cooke and a new species of Tilletia parasitic on rice-plant. Tōkyō Bot. Mag. **10**: 20. 1896.

[3] PATOUILLARD, Champignons extra européens. Bull. Soc. Myc. France **3**: 124. *pl. 10. fig. 2.* 1887.

[4] Bot. Centralblatt **65**: 97. 1896.